



1364 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Cycle: 1, Proposal Category: ERS

INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
Prof. Misty C. Bentz (PI)	Georgia State University Research Foundation	bentz@astro.gsu.edu
Dr. Christopher A. Onken (CoI)	Australian National University	onken@mso.anu.edu.au
Dr. Monica Valluri (CoI)	University of Michigan	mvalluri@umich.edu
Ms. Caroline Roberts (CoI)	Georgia State University Research Foundation	roberts@astro.gsu.edu
Dr. Merida Batiste (CoI)	Georgia State University Research Foundation	batiste@astro.gsu.edu
Eugene Vasiliev (CoI) (ESA Member)	University of Cambridge	eugvas@lpi.ru

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	Galaxy	NIRSpec IFU Spectroscopy	(1) NGC-4151
	2	Template Star	NIRSpec IFU Spectroscopy	(2) TYC-3986-834-1
	3	Template Star	NIRSpec IFU Spectroscopy	(3) BD+04-3653
	4	Template Star	NIRSpec IFU Spectroscopy	(4) 2MASS-J15395077-3404566
	5	Template Star	NIRSpec IFU Spectroscopy	(6) 2MASS-J17540383-2810466

ABSTRACT

Integral field spectroscopy has become an invaluable tool for investigating the physical conditions and dynamics deep inside galaxy nuclei. The integral field spectrograph on JWST provides some crucial advantages over those on AO-assisted ground-based telescopes like Gemini and VLT. In particular, JWST will provide a stable and diffraction-limited point spread function (PSF) with no seeing halo, and the background will be

significantly reduced resulting in shorter exposure times to achieve a benchmark signal-to-noise ratio, even for late-type galaxies that have shallower central cusps and fainter central surface brightnesses, and for which the exposure times required from the ground may be prohibitive. We are particularly interested in comparing black hole masses derived from the modeling of nuclear stellar dynamics to masses derived from reverberation mapping in the same galaxies. With this Early Release Science proposal, we request a small investment of time to clearly demonstrate JWST's capabilities in spatial and spectral resolution relative to the stringent technical requirements for direct black hole mass measurements. The technically demanding nature of the requisite measurements will allow us to explore the limits of what is possible to achieve with the NIRSpec IFU, thus providing technical guidance for a wide range of studies that seek to probe the physics of black hole feeding and feedback and their links to galaxy and black hole co-evolution.

OBSERVING DESCRIPTION

We will employ the G235H+F170LP grating and filter pair, providing spectral coverage over the wavelength range 1.66-3.17microns. The resolving power of the grating increases as a function of wavelength, from $R \sim 2200$ at 1.66 μm to $R \sim 4400$ at 3.17microns. While we will focus on the strong CO bandhead absorption lines at 2.3-2.5microns, we will also search for OH absorption features at ~ 2.8 microns and ~ 2.95 microns where the spectral resolution will be nearing its maximum. We will employ a four-point dither strategy using the small CYCLE dither option to allow the PSF to be subsampled at the 0.025" level.

We utilized the JWST ETC to estimate the exposure time required to achieve $S/N > 30-40$ per spatial element. We find that the NRS IRS2Rapid readout mode with an exposure time of 1.5 hours (estimated with 67 groups, 1 integration, and 12 exposures or dither positions) will provide $S/N = 80$ at $\lambda = 2.4$ microns and $S/N = 60$ at $\lambda = 2.9$ microns in the center of the galaxy for an aperture size of $0.025'' \times 0.025''$ (estimated with a circular aperture of radius 0.014"). In our analysis of the stellar dynamics, we plan to employ adaptive spatial binning, which will preserve the sampling in the center of the galaxy where the signal is strongest, but will employ successively larger bins to maintain a constant S/N as the radius from the center increases and the signal decreases. An estimated bin size of $0.1'' \times 0.1''$ at a radius of 1.0" from the center will provide similar S/N at the wavelengths of interest described above: $S/N = 70$ at $\lambda = 2.4$ microns and $S/N = 50$ at $\lambda = 2.9$ microns.

We will also observe four velocity template stars that were chosen to span a range of spectral types that are likely to contribute large fractions of the 2-3microns stellar light. For the template stars, we are not concerned with the spatial characteristics of the IFU, but only with the spectral characteristics. While more template stars always helps with increased accuracy and avoidance of template mismatch, we have limited our selection to what we believe to be the minimum necessary to accomplish our goals (four stars) because of the large overheads associated with slewing to each new target. Using the ETC with the same instrument setup as described above and assuming a late-type giant star model spectrum normalized to $K =$

JWST Proposal 1364 (Created: Friday, November 26, 2021 at 5:00:10 PM Eastern Standard Time) - Overview

10.0mag, we were able to estimate S/N ~ 300 with no saturation problems using a 4-point dither and the NRS IRS2Rapid readout mode with 3 groups, 1 integration, and 1 exposure, or an exposure time of 132s.

Proposal 1364 - Targets - Nuclear Dynamics of a Nearby Seyfert with NIRSpect Integral Field Spectroscopy

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	NGC-4151	RA: 12 10 32.5834 (182.6357642d) Dec: +39 24 21.03 (39.40584d) Equinox: J2000		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Spiral galaxies]</i></p>				
(2)	TYC-3986-834-1	RA: 22 23 50.2960 (335.9595667d) Dec: +54 29 31.05 (54.49196d) Equinox: J2000		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[K giants]</i></p>				
(3)	BD+04-3653	RA: 18 13 19.3368 (273.3305700d) Dec: +05 00 34.66 (5.00963d) Equinox: J2000		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[K giants]</i></p>				
(4)	2MASS-J15395077-3404566	RA: 15 39 50.7780 (234.9615750d) Dec: -34 04 56.67 (-34.08241d) Equinox: J2000		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[M giants]</i></p>				
(6)	2MASS-J17540383-2810466	RA: 17 54 3.8390 (268.5159958d) Dec: -28 10 46.62 (-28.17962d) Equinox: J2000		
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[M giants]</i></p>				

Fixed Targets

Proposal 1364 - Observation 1 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Fri Nov 26 22:00:11 GMT 2021

Observation	<p>Proposal 1364, Observation 1: Galaxy</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
Diagnostics	(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(1)	NGC-4151	RA: 12 10 32.5834 (182.6357642d) Dec: +39 24 21.03 (39.40584d) Equinox: J2000									
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Galaxy</i></p> <p><i>Description=[Active galactic nuclei, Spiral galaxies]</i></p>											
Template	TA Method											
	NONE											
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	CYCLING		SMALL	1			12				
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	G235H/F170LP	NRSIRS2	13	1	false	true	NONE	12	12	11554.401	12859.09
	2	G235H/F170LP	NRSIRS2	13	1	true	true	NONE	12	12	11554.401	12859.09

Proposal 1364 - Observation 2 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Fri Nov 26 22:00:11 GMT 2021

Observation	<p>Proposal 1364, Observation 2: Template Star</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
Diagnostics	(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(2)	TYC-3986-834-1	RA: 22 23 50.2960 (335.9595667d) Dec: +54 29 31.05 (54.49196d) Equinox: J2000									
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Star</i></p> <p><i>Description=[K giants]</i></p>											
Template	TA Method											
	NONE											
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	G235H/F170LP	NRSRAPID	3	1	false	true	NONE	4	4	171.788	

Proposal 1364 - Observation 3 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Fri Nov 26 22:00:11 GMT 2021

Observation	<p>Proposal 1364, Observation 3: Template Star</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
Diagnostics	(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(3)	BD+04-3653	RA: 18 13 19.3368 (273.3305700d) Dec: +05 00 34.66 (5.00963d) Equinox: J2000									
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Star</i></p> <p><i>Description=[K giants]</i></p>											
Template	TA Method											
	NONE											
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	G235H/F170LP	NRSRAPID	3	1	false	true	NONE	4	4	171.788	

Proposal 1364 - Observation 4 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Fri Nov 26 22:00:11 GMT 2021

Observation	<p>Proposal 1364, Observation 4: Template Star</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
Diagnostics	(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(4)	2MASS-J15395077-3404566	RA: 15 39 50.7780 (234.9615750d) Dec: -34 04 56.67 (-34.08241d) Equinox: J2000									
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Star</i></p> <p><i>Description=[M giants]</i></p>											
Template	TA Method											
	NONE											
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	G235H/F170LP	NRSRAPID	3	1	false	true	NONE	4	4	171.788	

Proposal 1364 - Observation 5 - Nuclear Dynamics of a Nearby Seyfert with NIRSpec Integral Field Spectroscopy

Fri Nov 26 22:00:11 GMT 2021

Observation	<p>Proposal 1364, Observation 5: Template Star</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec IFU Spectroscopy</p>											
Diagnostics	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.											
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous			
	(6)	2MASS-J17540383-2810466	RA: 17 54 3.8390 (268.5159958d) Dec: -28 10 46.62 (-28.17962d) Equinox: J2000									
	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Star</i></p> <p><i>Description=[M giants]</i></p>											
Template	TA Method											
	NONE											
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
Spectral Elements	#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	G235H/F170LP	NRSRAPID	3	1	false	true	NONE	4	4	171.788	